TOXIC CHEMICALS IN THE ST.LAWRENCE RIVER

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ABSTRACT

This presentation deals with the St.Lawrence River as it flows through the Quebec Province between Cornwall and Quebec City. Government and private agencies have carried out various studies on the river's water quality, which identified the dissemination of toxic chemicals as one of the major problems. Certain parts of the river, notably Lake St.Francis, Lake St.Louis south, and the southern section of the river between Montreal and Sorel, were found to be particularly contaminated. An intensive sediment survey in Lake St. Francis showed the lake to be contaminated by PCB's, and to a lesser extent, by mercury. Spatial distribution patterns indicated that the Cornwall region is a significant source of mercury, while high PCB's and PAH levels originate from New York tributaries of the international section. However, the presence of mirex and the relatively high concentrations of PCB's throughout the whole lake indicate a significant contribution from Lake Ontario. Particle size distribution suggests that the lake does not act so much as a contaminant sink, but that a significant fraction of toxic chemicals entering the lake moves on towards the Montreal area.

INTRODUCTION

This presentation deals with the St. Lawrence River as it flows through the Quebec Province between Cornwall and Quebec City, focusing on toxic chemicals, especially Hg and PCB's and their distribution throughout the river, using concentrations in fish. Special attention will be paid to Lake St. Francis (lac Saint-François), where an intensive sediment survey was carried out in 1979-81.

THE TERRITORY (fig. 1 and 2)

The St. Lawrence River is a very important waterway, presenting about 1000 km of water between Lake Ontario and the Gulf. It is complex in its hydrological and geomorphological characteristics, rich in biological resources, important for navigation and recreational activities, but receiving the full impact of environmental degradation by industrial and agricultural activities and by untreated domestic sewage discharges.

The river enters the Quebec Province at Cornwall. It originates in Lake Ontario and forms the international boundary between Kingston and Cornwall. In the Montreal area, it joins up with the Ottawa River. There is little cross-sectional mixing, so the two types of water can be easily distinguished as far downstream as Lake St. Pierre.

The water from the Ottawa River is higher in colour, turbidity, organic matter and nutrients, but lower in conductivity, than the waters originating from the Great Lakes. This duality of the river is an important and significant aspect: the problem of toxic chemicals is associated more with the Great Lakes water than with the Ottawa River water. In the following section we will present results that underline this aspect.

GENERAL CONTAMINATION PATTERN (Hg, PCB)

In figure 3, a portrait of mercury contamination in fish throughout the river between Cornwall and Quebec City is presented. We have separated stations located in the brown Ottawa River water (in the figure on the left) from those located in the blue-green Great Lakes water. Piscivores represent data combined for pike (brochet) and walleye (doré jaune), while benthivores represent white sucker (meunier noir) and brow bullhead (barbotte brune); insectivores represent pumpkinseed sunfish (crapet-soleil) and yellow perch (perchaude).

It is evident that the Montreal area is the most contaminated stretch of the river, expecially along the southshore. Besides various local and upstream sources (Montreal, Cornwall, Great Lakes), there is an important point source on the southshore of Lake St. Louis, a chlor-alkali plant using mercury as an electrode. Lake St. Francis is also quite contaminated but to a lesser extent than the Montreal area. Downstream towards Quebec City, contamination is gradually decreasing.

In figure 4 is presented PCB contamination in the same manner as for Hg. However, the distribution pattern is quite different. In this case, Lake St. Francis is the most contaminated part of the river. Montreal does contribute significantly, but only into the brown Ottawa River waters, where most of its urban effluents are discharged. Still, these waters do not become as contaminated as Lake St. Francis. Since there is no industry around this lake, except Cornwall and Valleyfield,it is felt that upstream sources, Lake Ontario and the the international section, have a significant impact on the first stretch of the river in the Quebec Province. To explore a little more in detail this stretch of the river, we shall discuss sediment data in the next section.

DISTRIBUTION OF CONTAMINANTS IN LAKE ST.FRANCIS SEDIMENTS

Lake St. Francis is formed by a widening of the St. Lawrence River after entering the Quebec Province at Cornwall (figure 5 and 5a). It receives the waters of the Great Lakes by way of the international section leaving Lake Ontario (Kingston - Cornwall). It drains one of the most industrialized and urbanized areas of North-America. It is well known that Lake Ontario is quite contaminated by toxic substances. Add to this tributaries draining a highly industrialized area of New York, and Lake St. Francis is potentially one of the most contaminated waterbodies in Quebec.

In order to determine whether Lake St. Francis acts as a sink for toxic substances coming from Lake Ontario and the international section of the St. Lawrence River, a sediment survey was carried out in 1979, 1980 and 1981. About a hundred stations located throughout the lake following more or less a sampling grid, were sampled for bottom sediments, using a 15 X 15 cm Ekman dredge. The first 3-4 cm were taken and subsequently analyzed for particle size, organic carbon and total nitrogen, mercury and PCB/OC. About 30 stations were also analyzed for PAH's, while 10 were analysed for chlorobenzenes, pentachlorophenol and PBB's.

Results indicate that PBB's and pentachlorophenol were not present, and chlorobenzenes to be close to detection levels (1 ng/g).
Most of the chlorinated pesticides were near or below detection limits, except total DDT, HCB and chlordane, which were found at concentrations up to 17, 13 and 5 ng/g, respectively. Mirex was detected at a few stations only, the maximum concentration being 3.3 ng/g.

In figure 6, 7 and 8 are presented results for Hg, PCB and PAH. Two contaminants were found at high concentrations, namely PCB's and Hg. PCB concentrations varied between 1 and 1900 ng/g, with a median of 170 ng/g, while Hg concentrations were between 1 and 1474 ng/g, with a median of 134 ng/g.

PAH's were found at significant concentrations, up to about 1000 ng/g. Three carcinogens are included in the list of PAH's analysed, benz(a)antracene, benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene, which were found at concentrations up to 120, 770 and 900 ng/g, respectively.

The distribution pattern for PCB's and PAH's indicate high concentrations along the south shore, while mercury concentrations were high along the north shore. It is concluded from this that Lake Ontario may have less an impact on the Quebec part of the St. Lawrence River than was previously suspected. Local sources such as Cornwall and the New York tributaries of the international section of the St. Lawrence are probably responsible for the observed distribution patterns.

However, the fact that mirex was found in significant quantities and that PCB concentrations are high throughout the whole lake, indicates that Lake Ontario remains a significant source of organic contaminants.

Particle size distribution suggests that Lake St. Francis is governed more by fluvial than lacustrine conditions, sand being the predominant fraction at most stations. This then indicates that the lake does not act so much as a contaminant sink, but that a significant fraction of toxic substances entering the lake from upstream move through the system and out towards the Montreal area.

ADDITIONAL STUDIES ON PCB'S (minnows, water)

In order to determine whether PCB concentrations in water showed a pattern throughout Lake St. Francis, a preliminary study, using minnows as a bio-indicator, was carried out in 1979. Results are shown in figure 9. Concentrations are higher along the southshore, confirming our previous conclusions that the New York tributaries of the international section constitute an important source of PCB's.

In figure 10 are shown results from water analyses at stations in the Cornwall area. We have shown frequency of positive results (i.e. above the detection limit of 10 ppt) and the maximum value observed. The higher values were registered again near the southshore.

CONCLUSIONS

One of the major problems concerning the St. Lawrence River is the dissemination of toxic chemicals. It has been shown that there is a rough gradient between Cornwall and Quebec City, the river becoming less contaminated going downstream. However, PCB levels observed in fish caught near Quebec City indicate a significant long-range transport of pollutants.

The problem of toxic chemicals seems to be associated more with waters originating from the Great Lakes than those coming from the Ottawa River. Nevertheless, the Montreal area is a significant source of contaminants, contributing toxic chemicals mainly to the brown Ottawa River water.

Sediments studies in Lake St. Francis showed that there is a significant transport of organic contaminants coming from Lake Ontario. There is, however, also a significant contribution from the international section, which has a greater immediate impact on the system under study. The survey indicated as well that there may be a significant transport of toxic chemical towards the Montreal area.

FUTURE CONSIDERATIONS

There still needs to be done a lot of work. Even though, toxic chemicals and the St. Lawrence River have been respectively identified as a national and regional priority, we are still being hampered by lack of resources. Nevertheless, a list of future work that should be carried out for the St. Lawrence River concerning toxic chemicals is included. It must be stressed that we plan to extent beyond the traditional Hg and PCB to other important priority chemicals.

We recommend the following studies:

1. complete sediment survey for the whole river (Cornwall-Quebec City); this should include chemical and biological evaluation of toxic chemicals; studies should concentrate on accumulation zones, such as the various widenings (lakes) of the river.

2. use minnows for biomonitoring; young-of-the-year spottail shiner and yearling perch seem to be promising indicator species for determining spatial and temporal trends; yearling perch might be used to evaluate stress as related to body burden.

3 evaluate the presence of certain priority chemicals throughout the river by means of adult fish as bio-indicators; most compounds of interest are organic and very lipophilic, these would be the easiest to detect if one uses adult fish.

4. trend assessment of Hg and PCB; government regulations have been in effect since a number of years, it is now important to determine whether the environment has responded; Lake St. Francis and Lake St. Louis are to be target areas, since Hg and PCB are a problem in these waterbodies; fish (adult and/or minnows) are to be used as indicators.

5. Mass loading studies of toxic chemicals; since most toxic chemicals are below detection limits, means of <u>in situ</u> concentration have to be investigated (e.g. continuous-flow centrifuge, extraction columns); long range aquatic transport of pollutants originating from the Great Lakes and the international section of the river has to be evaluated with reference to its contribution to contamination problems in the Quebec stretch of the St. Lawrence River; contributions from the Montreal area, and possibly from the Ottawa River have to be quantified as well.

For the 1984-85 activities for the Water Quality & Quantity Programs of the Inland Waters Directorate, the following studies in Lake St. Louis will be undertaken:

1. Sediment Survey: about 50 stations throughout the lake will be sampled once during the summer; samples will be analysed chemically for: heavy metals, Hg, PCB/OC, PAH, chlorobenzenes, and chlorophenols. Biological analyses include bacteriology of the sediments (respiration, heterotroph activity, N- and S-cycle bacteria, ATP biomass) and evaluation by means of bioassays (Microtox, algae, zooplankton, nematodes) of a sediment elutriate (1 vol. sediments mixed with 4 vol. water, settling, filtration of supernatant: elutriate).

2. Minnows (young-of-the-year spottail shiner, yearling perch): chemical analyses for heavy metals, Hg, and PCB/OC; biological analyses involve backbone analyses by X-ray and by biochemical techniques. It is hoped that backbone stress may be correlated to body burden; minnows will be caught at 10 locations throughout the lake in order to determine whether there is a relationship between site-of-capture (and known sources of contaminants) and body-burden levels.

In closing, it seems appropriate to say a few words on biomonitoring of toxic substances in the environment. This paper has dealt with what might be called "Ambient Level Monitoring", which tells us how much of a given substance is present in a particular environment. However, it does not qualify this information nor determine whether there is a significant impact on the ecosystem.

Therefore, there is an urgent need to develop the tools and methods to study toxic effects or stress factors in the natural environment. Bioassays are now carried out using very sensitive and refined techniques, but they are mainly limited to particular toxic chemicals or industrial effluents. These studies are important, and they do provide much information, but it is still very difficult to predict the effects of toxic chemicals that are being found in a particular ecosystem. Ecotoxicology is a popular concept today, yet, if we do not address real ecosystems in the field, but only in the laboratory, then the term ecotoxicology loses its true meaning.

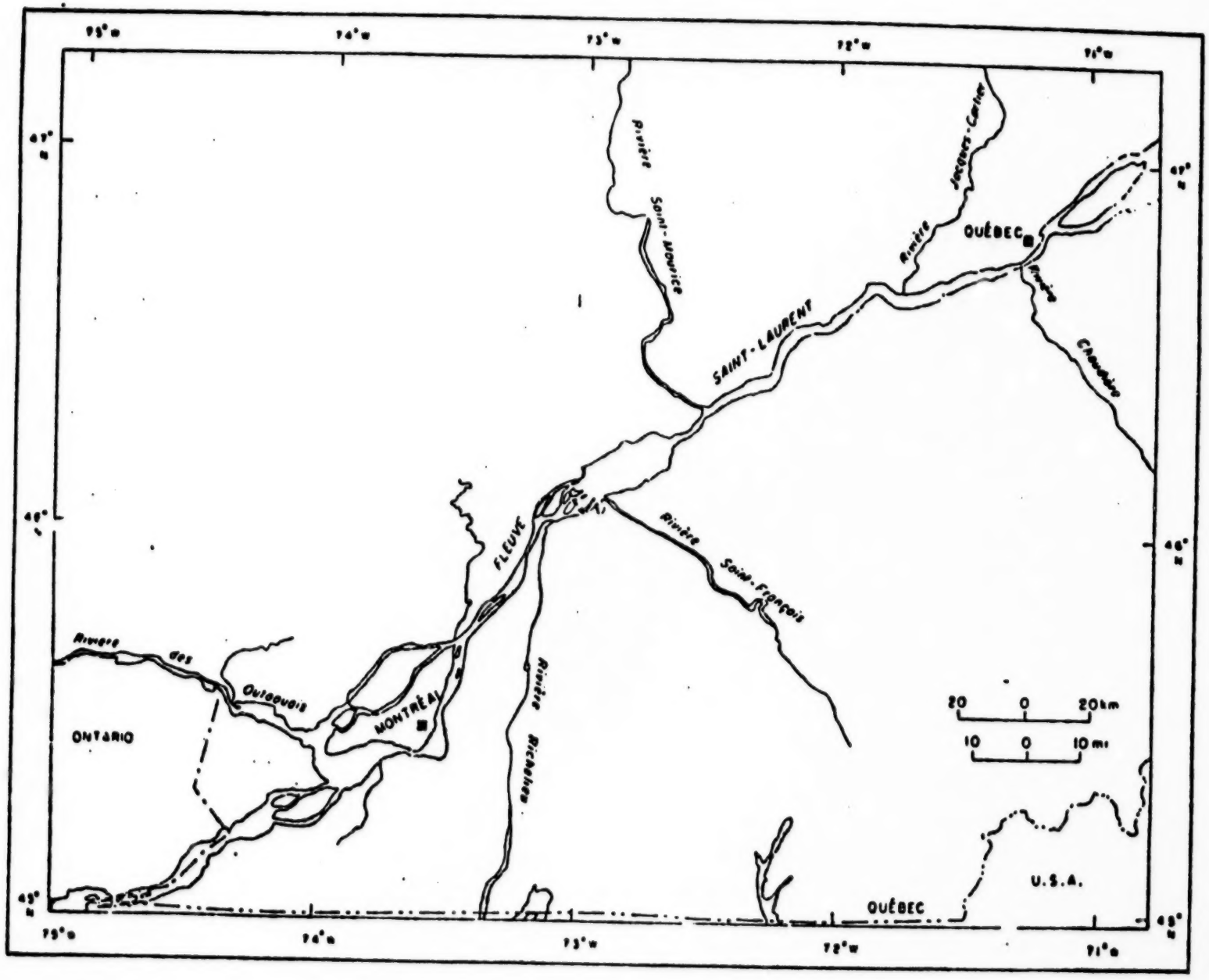


Figure 1: St. Lawrence River, Quebec Region

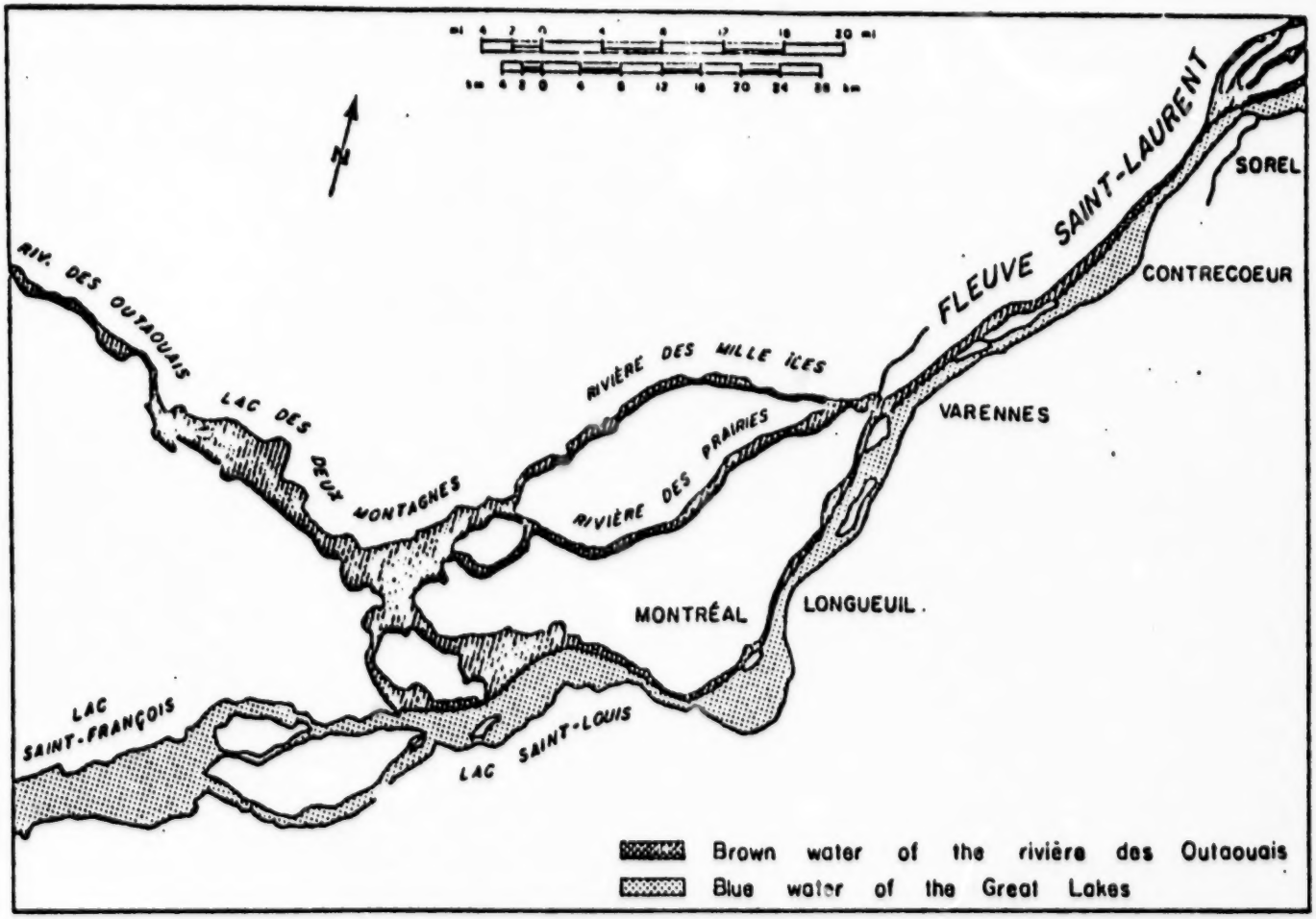


Fig. 2: The two basic types of water in the St. Lawrence River, Montréal region.

Figure 3: Moyennes (ajustées par la méthode d'analyse de covariance), écarts-types et valeurs minimums et maximums des concentrations de mercure total dans la chair des poissons piscivores, benthivores et insectivores du fleuve Saint-Laurent

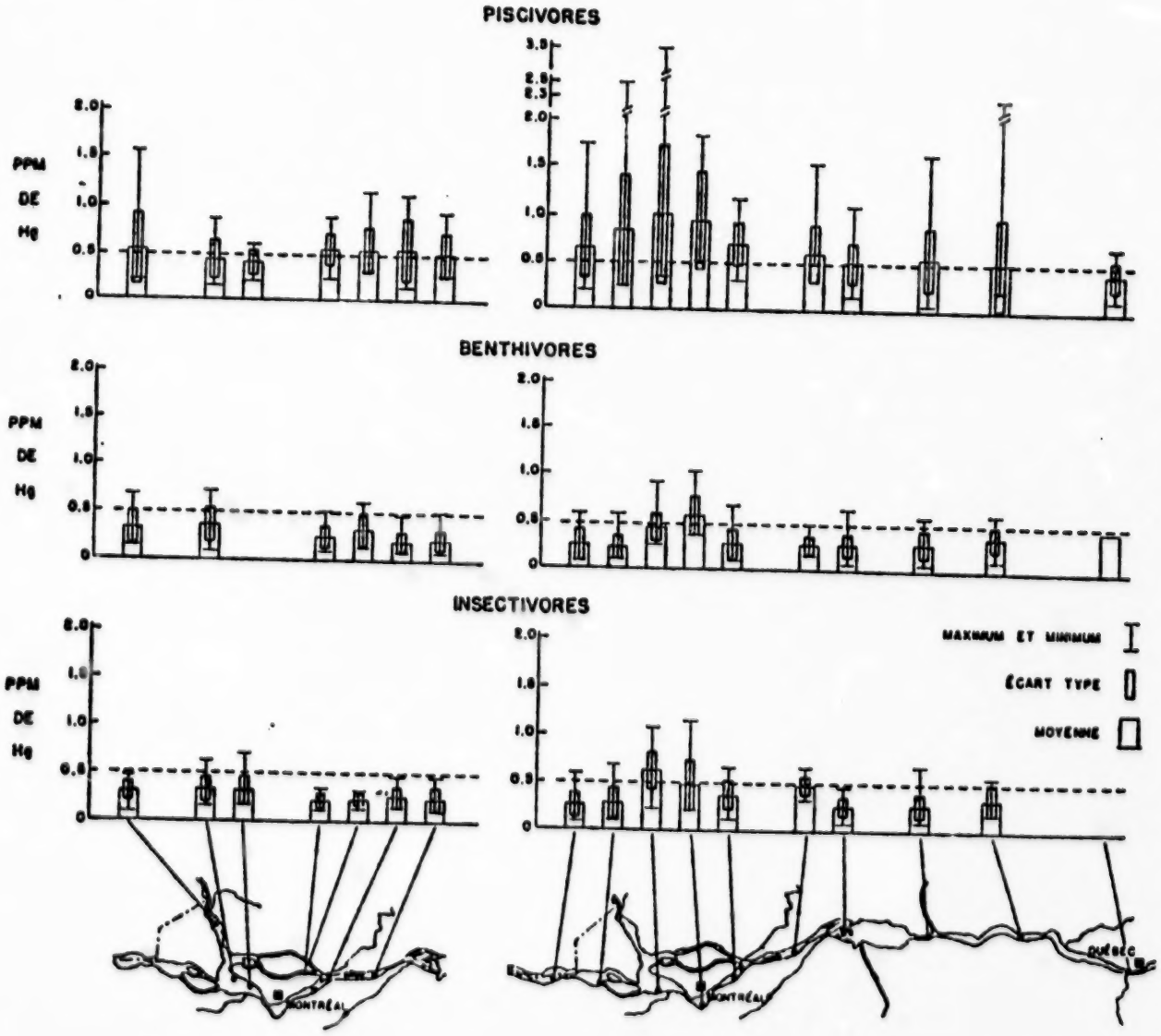
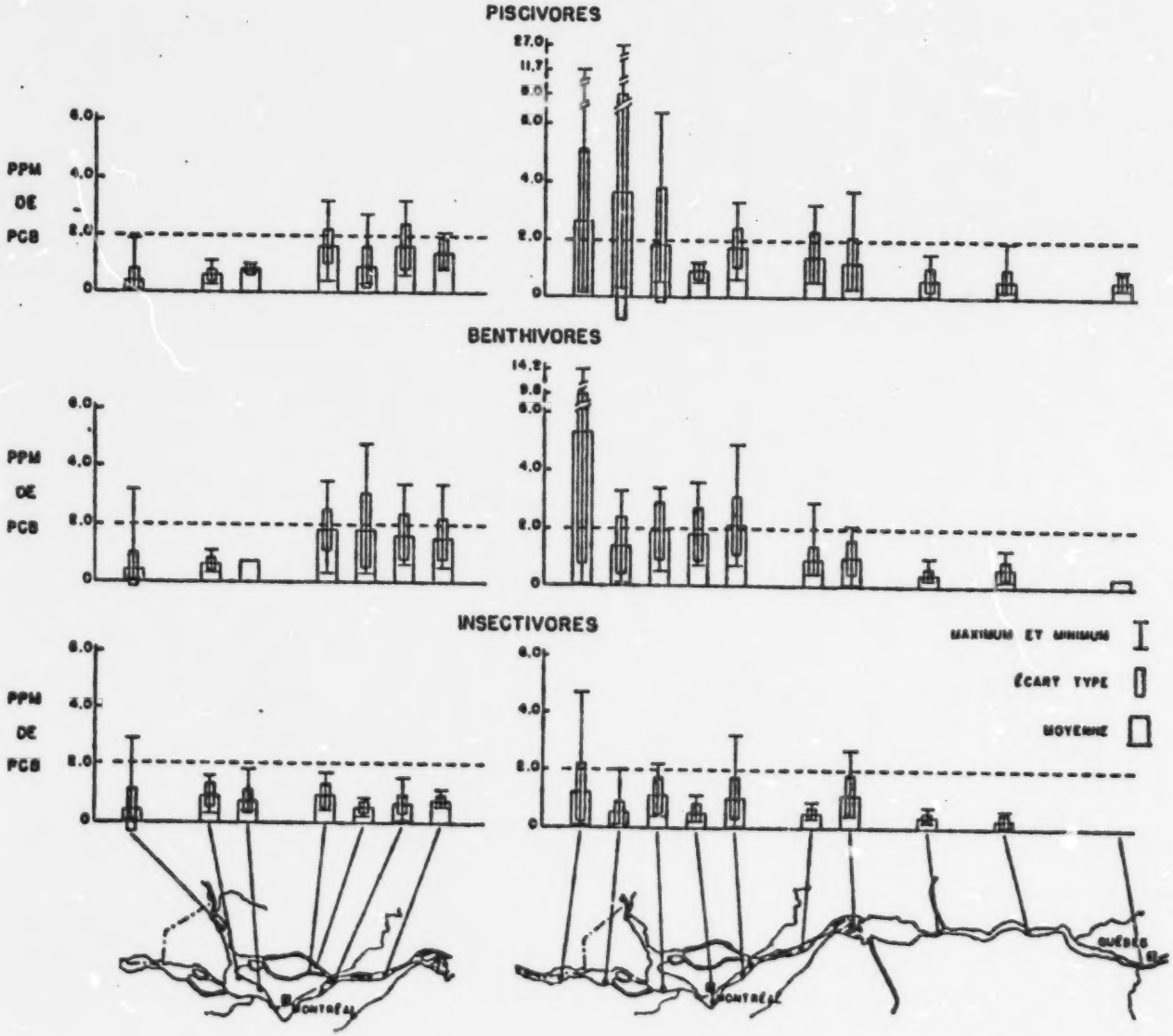


Figure 4: Moyennes, écarts-types et valeurs minimums et maximums des concentrations de PCB dans la chair des poissons piscivores, benthivores et insectivores du fleuve Saint-Laurent



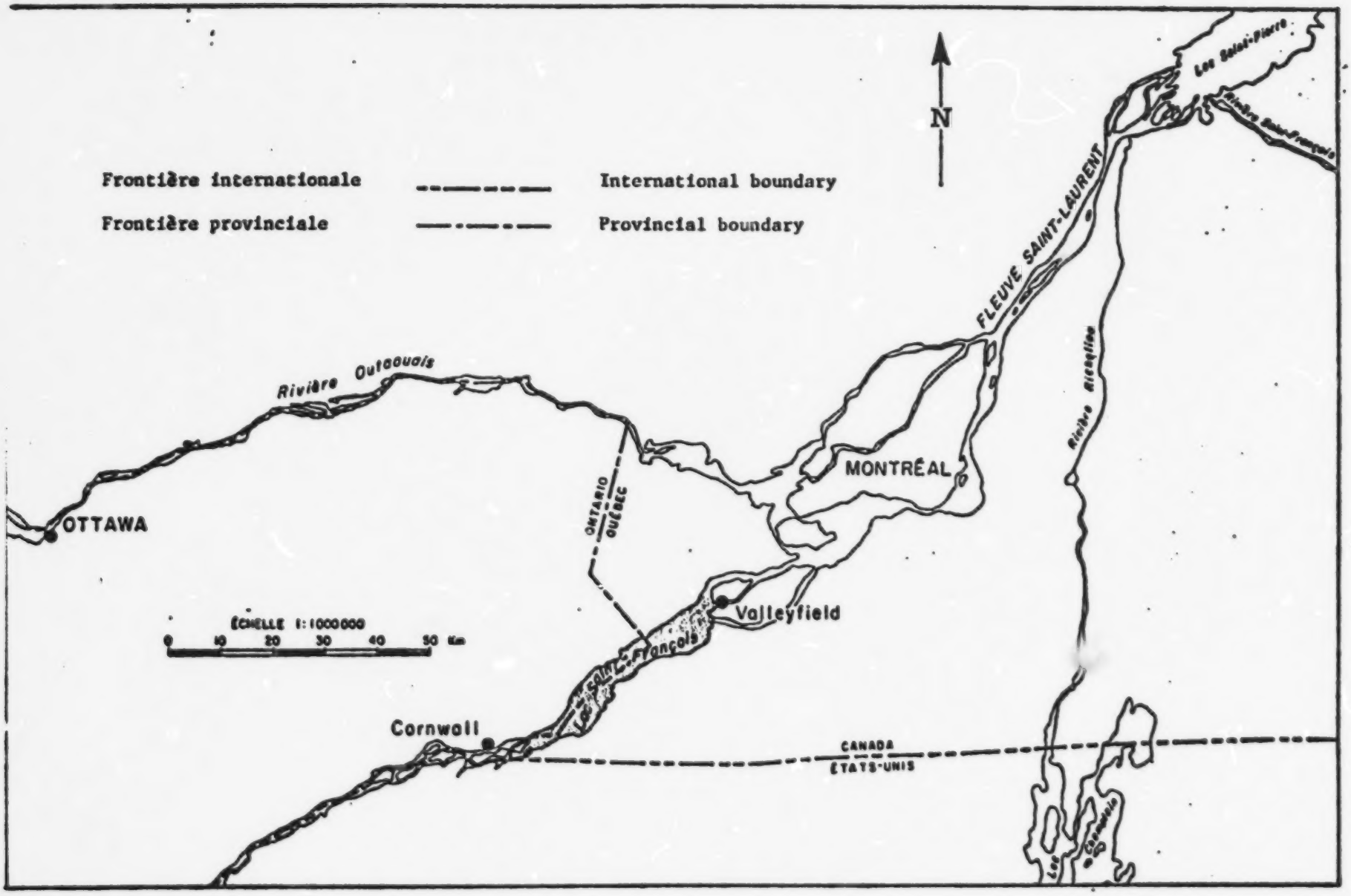


FIGURE 3. Lake St. Francis location

Figure 5a: Lake St. Francis

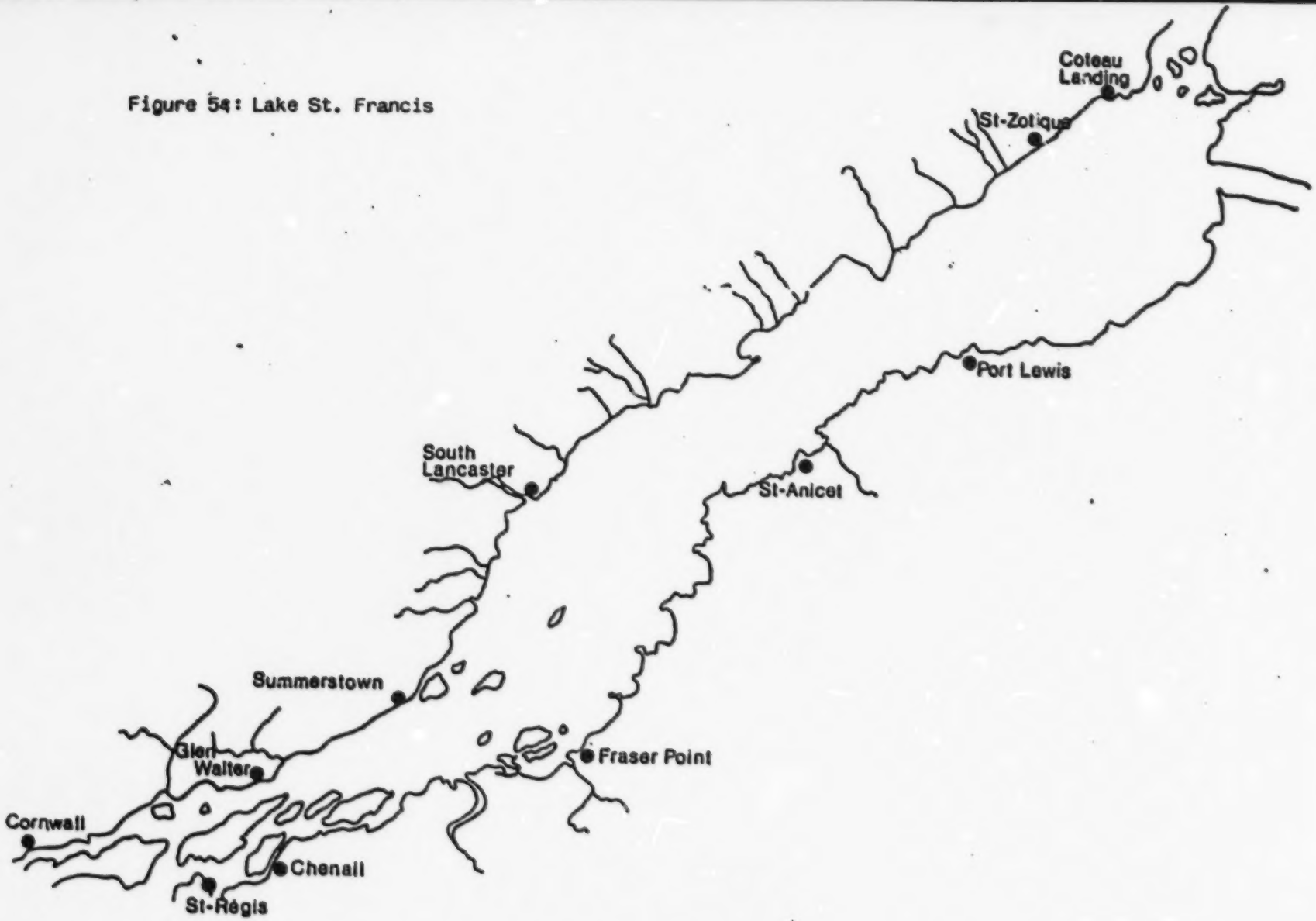


Figure 6: Hg concentrations in sediments

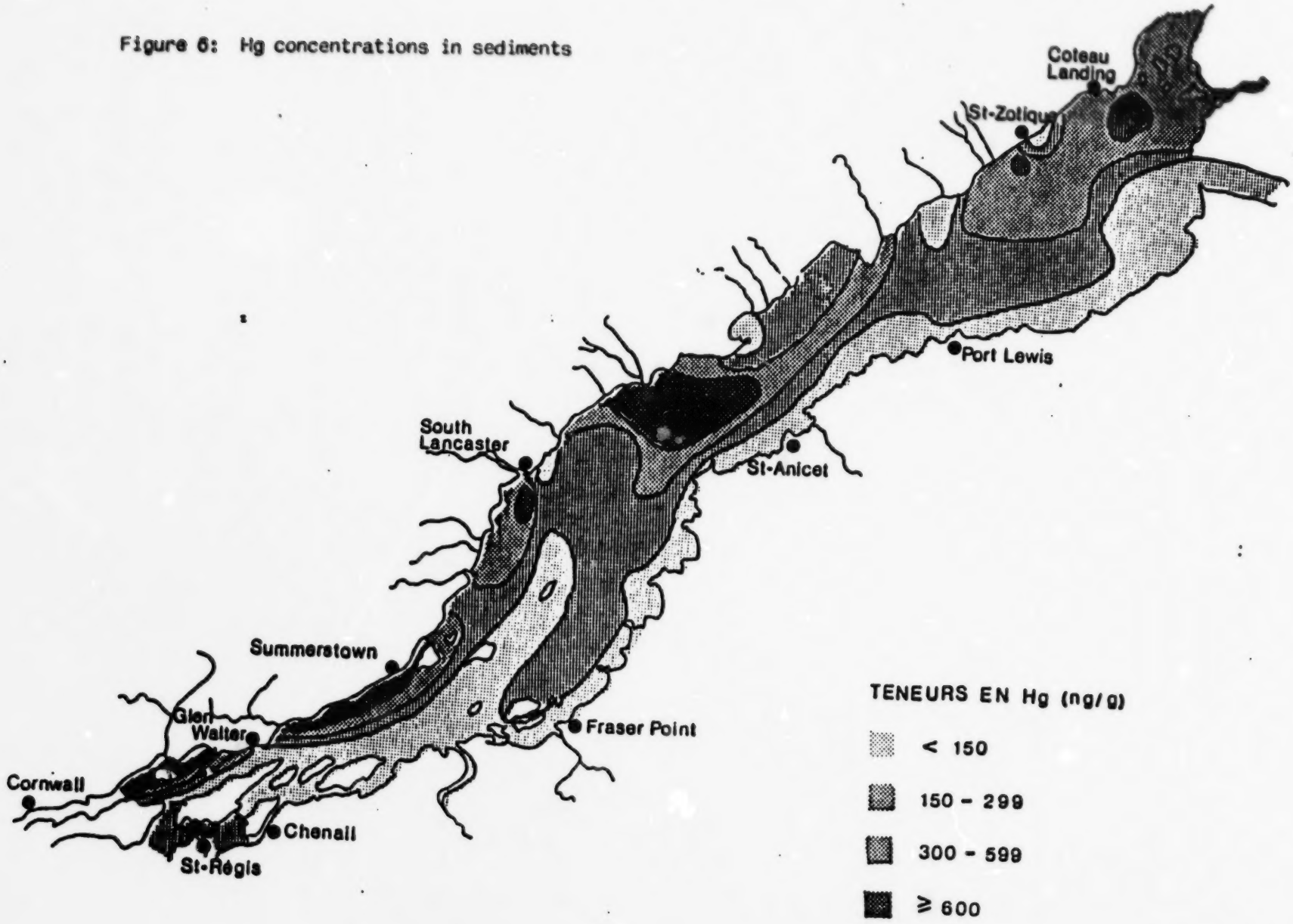


Figure 7: PCB concentrations in sediments

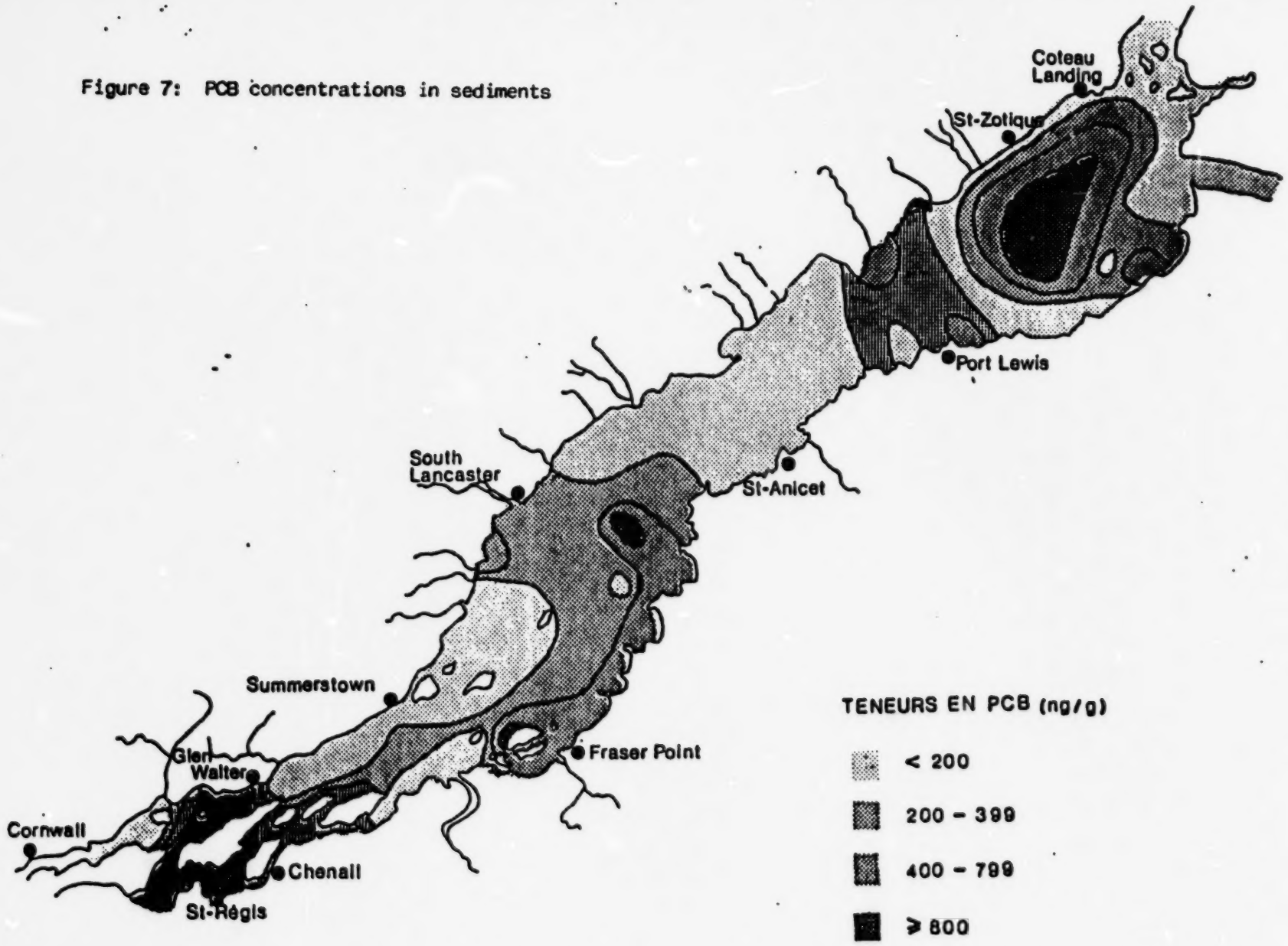


Figure 8: Total PAH concentrations in sediments

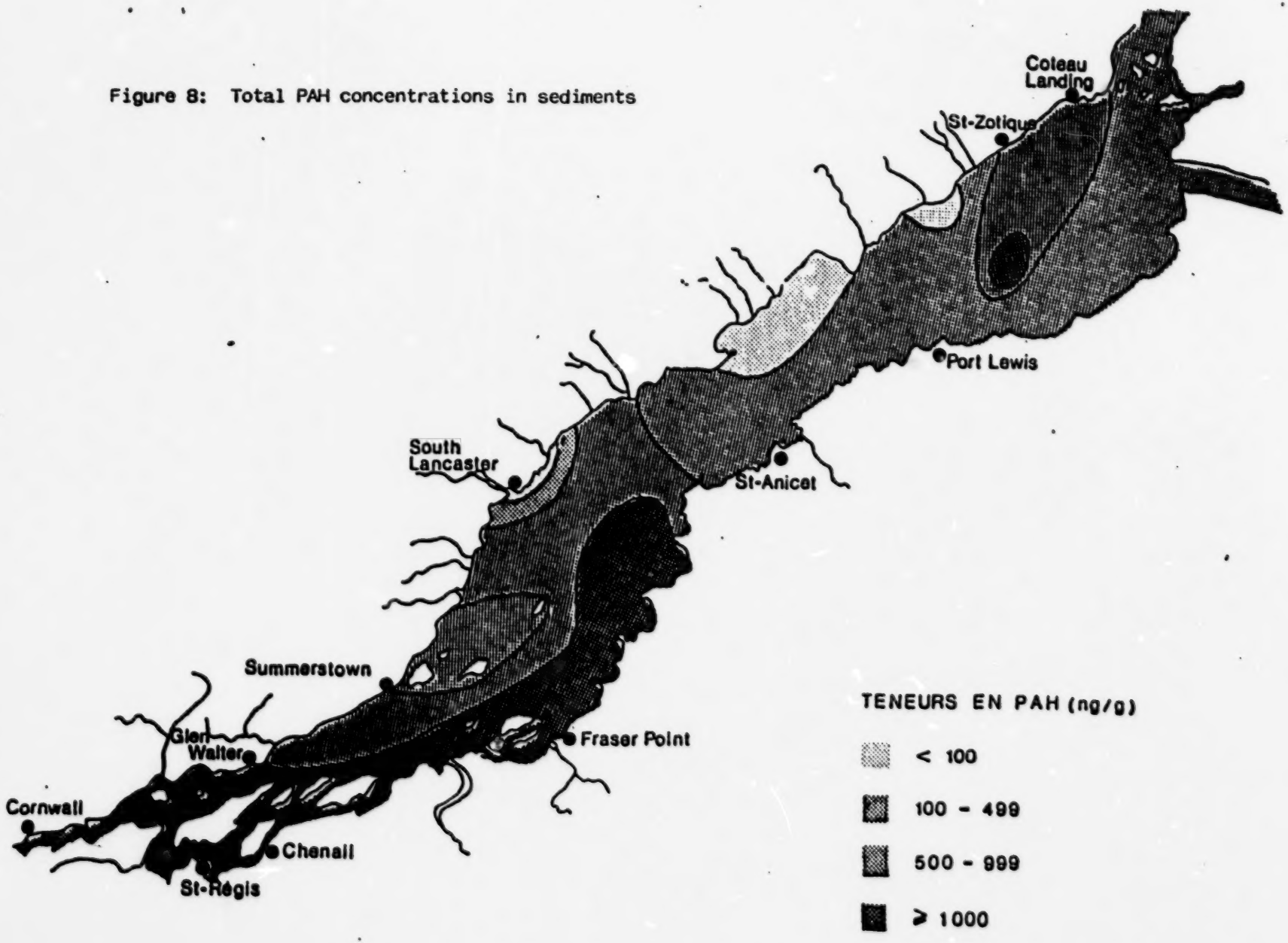
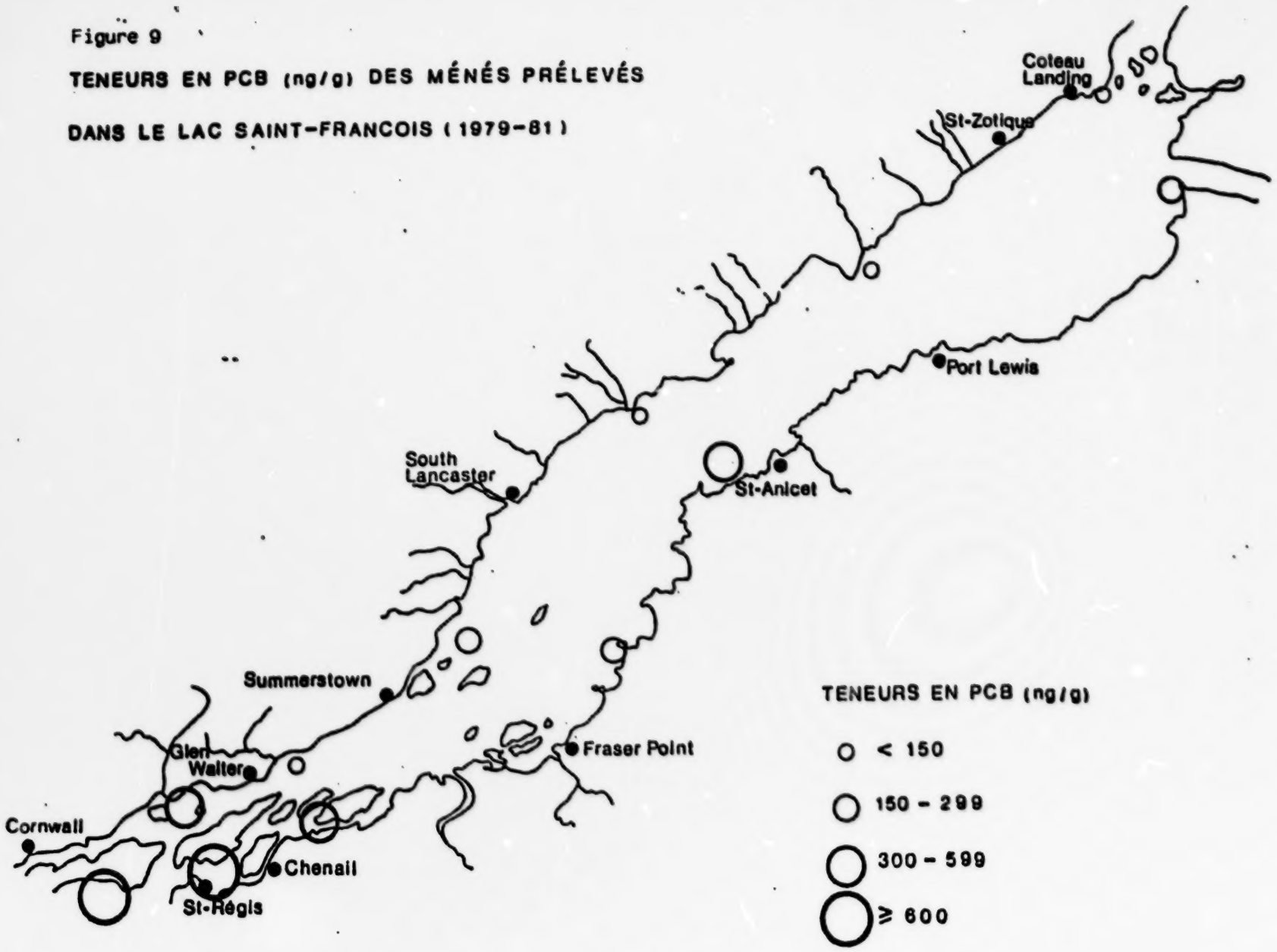


Figure 9

TENEURS EN PCB (ng/g) DES MÉNÉS PRÉLEVÉS

DANS LE LAC SAINT-FRANCOIS (1979-81)



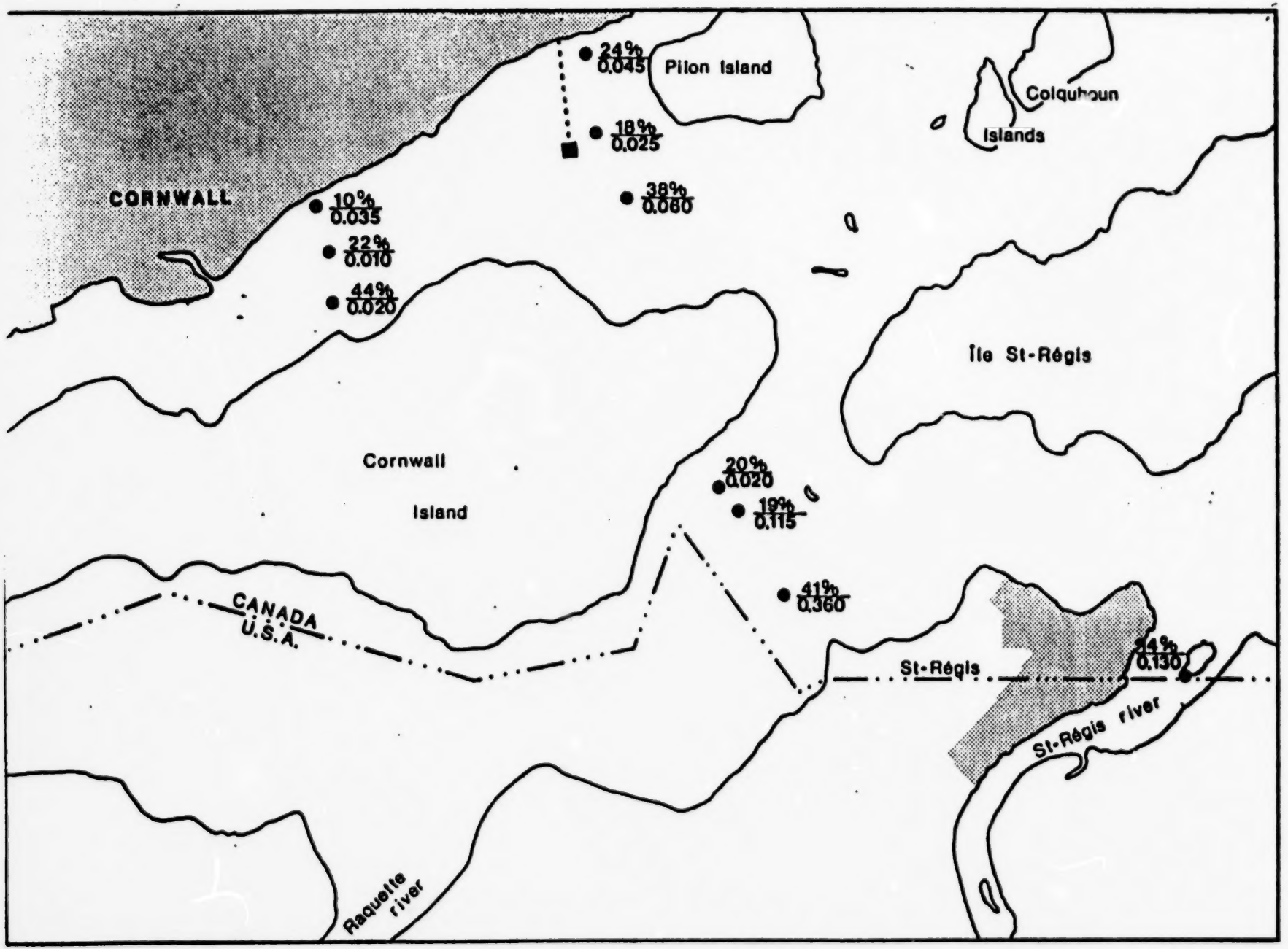


Figure 10: PCB in water: % of values above detection limits and maximum values observed